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A New Model-- The Dance of Construction

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diagnosed, motivated, reinforced; and posttested. The role of the teacher has become one of technician: diagnose the needs of the learner then present the correct sequence of objectives in the correct instructional mode. Even the teacher gets evaluated. Not only are the students' test scores used to validate what they have learned, but in some circles they are even considered an appropriate measure of the teacher's performance!

The implicit assumptions are obvious: parts add up to wholes and variables can be controlled and isolated given enough information and appropriate measuring tools. To wit, the technology has been too "yang", too assertive, too reminiscent of the science of Bacon, Descartes, and Newton. Little, or no, emphasis is placed on the a priori thought of the child. Instead the focus has been on the teacher's behaviors and the curriculum, on control of the learning situation and the learner. Only one person has been dancing, the teacher.

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Definition. The maturationist perspective, on the other hand, takes the stance that the innate program of development is of prime importance. All emphasis is placed on the child. Unfolding and growth are assumed to occur by biological programming.

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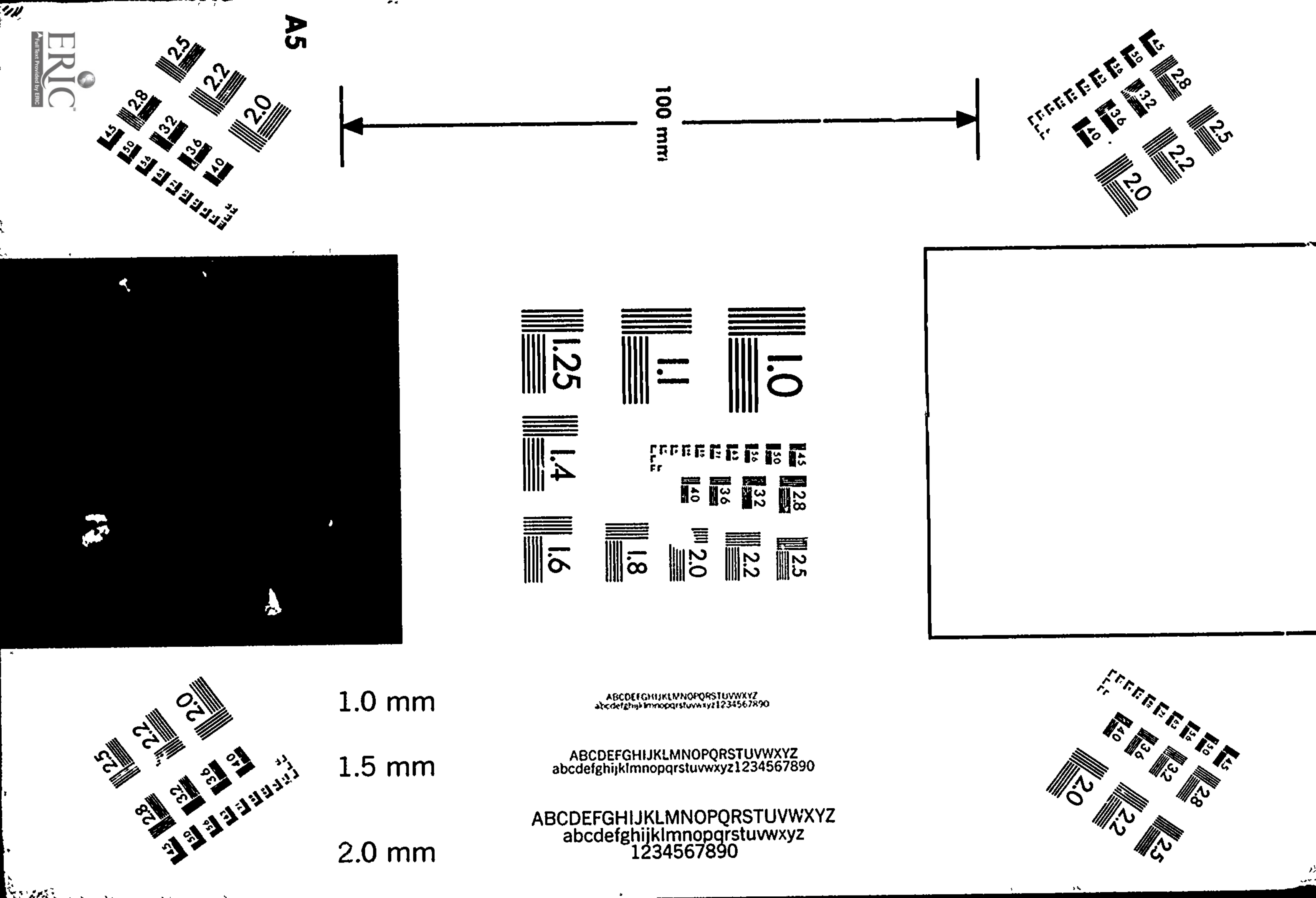
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ABSTRACT

This examination of the application of the products and processes of science to the field of education argues that education is entrenched in an outdated scientific mode--that of a Newtonian model--and proposes a more contemporary model of relativity which purports that wholes cannot be broken into parts, that variables are not isolatable but interrelated, and that change is a dance of interaction, organization, and adaptation. Piaget's early work in biology is explored and compared with his later work in cognitive structures. This later work is interrelated with the constructivist view, and this view is contrasted with empiricist and maturationist views of education. It is argued that a constructivist view of education requires learning to be child-centered, with the child constructing the knowledge and the teacher serving as a creative mediator. Finally, an example of the use of the constructivist approach in a K-2 classroom is given. The text is supplemented by two figures and 12 references. (EW)

The Dance of Education

Catherine Twomey Fosnot
Southern Connecticut State University

Paper presented at the annual conference of the Association for Educational Communication and Technology, New Orleans, Jan. 1988.

"Our minds encompass planetary movements, mark out geological eras, resolve matter into its constituent electrons, because our mentality is the transcendental expression of the age-old integration between ectoplasm and non-living world."

Earnest Everett Just, Biologist

"We cannot doubt the existence of an ultimate reality. It is the Universe forever masked. We are a part of an aspect of it, and the masks figured by us are the Universe observing and understanding itself from a human point of view."

Edward Harrison, Cosmologist

"The passion for science and the passion for music are driven by the same desire: to realize beauty in one's vision of the world."

Heinz Pagels, Physicist

Introduction

Science has long fingers. Because it reflects a way of thinking, it frames our imagination, our investigation, and our invention. The questions we ask, the manner in which we derive answers, and the eventual solutions proposed to problems all become exemplifications of the current scientific mode of thinking. Thus, science influences our technology, our politics, our research, and our institutions.

It is a commonly held assumption today that education should be a science. Point in fact, most universities and colleges of education bestow the degree of B.S., rather than B.A. on their graduates. Implicit in such an

assumption is the belief that the products and processes of science and technology can provide benefits, if not solutions, to the problems in the field of education. Yet, science has undergone some major paradigmatic changes during this century that need careful examination if educators are to attempt to apply principles from it.

This article begins with an overview of the changes in science, specifically physics, and ends with the proposition that education is currently entrenched with an outdated scientific mode of thought, that of a Newtonian model. It proposes that the more contemporary model of relativity be applied which purports that wholes can not be broken into parts, variables are not isolable but interrelated, and that change is a dance of interaction, organization, and adaptation.

Brief History of Science

During the Middle Ages science was based on a unification of reason and faith, its main goal being to understand the meaning and significance of natural phenomena. God, the human soul, and ethics were interwoven into a view of the world as organic and living because causal explanation and human or divine purpose were confused and superficial.

With the advent of the "Age of the Scientific Revolution" in the sixteenth and seventeenth centuries, a rigorous determinism became prevalent with objective relationships attributed to causal events, epitomized by the theories of Bacon, Descartes, and Newton. Bacon advanced the notion that "nature had to be hounded in her wanderings...bound into service and made a slave" (Capra, 1982, pg.56). He set forth the empirical method of induction, the expressed goal being to dominate and control nature. Descartes, with his famous idiom "Cogito, ergo sum" -- "I think, therefore I exist" encouraged a

division between mind and matter which led to a view of the universe as a mechanical system consisting of separate objects, fundamental building blocks whose properties and interactions were thought to determine all natural phenomena. A brilliant philosopher and mathematician, Descartes formulated the principles of deductive reasoning and set forth the framework of the cartesian coordinate system, both of which became the basis for a reductionist, empiricist view of the world. Newton cemented this perspective by describing space and time as "absolute... without regard to anything external" (Capra, 1982, pg. 65). His mechanics were based on certain principles of conservation which produced the idea that all that happened had a definite cause and effect, and that the future of any part of a system could be determined with absolute certainty if its present state was known in detail and the appropriate measurement tools were available.

Contemporary physics suggests a new paradigm. For example, Faraday and Maxwell while studying electric and magnetic forces discovered that it made more sense to talk about a "force field" rather than a force. They determined that each charge created a disturbance in the space around it so that the other charge felt a force. In contrast to Newton's theory, the force field had its own reality and could be studied without any reference to material bodies.

During the 1800's light was believed to be composed of waves. Thomas Young had shown convincingly that when a beam of light was projected through a razorlike slit (smaller in diameter than the wavelengh of the light), interference (diffraction) occured. This diffraction could only be explained by a wave theory. Planck and later Einstein proved, in contradiction to Young's theory, that light was composed of small particles (called photons) travelling in a similar fashion to billiard balls. When they hit an object

they hit an object they knocked a particle out of the mass of that object, just as a billiard ball hitting another would send it traveling at the same speed as the original ball. This proposal explained refraction and the photoelectric effect, whereas the wave interpretation had been insufficient, but a paradox remained. How could light be particles with mass, and yet be waves at the same time? Einstein resolved the contradiction by proving that light was both. He proposed that light is nothing but a rapidly alternating electromagnetic field traveling through space in the form of waves. Whether we perceive light as photons (having mass) or as waves depends on the observer, the question asked, and the measurement system used. Sachs comments on Einstein's theory...

> "The real revolution that came with Einstein's theory...was the abandonment of the idea that the space-time coordinate system has objective significance as a separate physical entity. Instead of this idea, relativity theory implies that the space and time coordinates are only the elements of a language that is used by an observer to describe his environment." (Sachs, 1969, pg. 53)

Present day quantum physicists have verified repeatedly Einstein's description of the effect of the observer and the interconnectedness of variables such as space, time, and momentum. Subatomic particles have been found by Heisenberg, Bohr and others to have no meaning as isolated entities. To the extent that a particle can be studied in terms of its placement in the atom, the momentum becomes ambiguous. And vice-versa. In other words particles are now understood as waves dancing between states of mass and energy. In the words of Neil Bohr, "Isolated material particles are

abstractions, their properties being definable and observable only through their interaction with other systems" (Capra, 1984, pg. 124).

Present day "Bootstrap" and "S-Matrix" theory physicists assert an even more radical perspective. In Capra's words,

> "Bootstrap philosophy constitutes the final rejection of the mechanistic world view in modern physics...In the new world view, the universe is seen as a dynamic web of interrelated events. None of the properties of any part of this web is fundamental; they all follow from the properties of the other parts, and the overall consistency of their mutual interrelations determines the structure of the entire web." (1982, pg. 93)

In essence, bootstrap philosophy accepts no laws at all except that of self-consistency. All the parts of matter must be consistent with each other. To that point Heisenberg states, (when we observe).. "What we observe is not nature itself, but nature exposed to our method of questioning."

The concept of mass as nothing but a form of energy, and particles, not as building blocks, but as "dynamic patterns continually changing into one another--the continuous dance of energy" has led some (Capra, 1982, 1976; Zukav, 1979) even to go so far as to suggest a parallel between current physics models and eastern mysticism, i.e. Taoism. In Taoism, change is not seen as occurring as a consequence of some force, but rather as a tendency which is innate in all things and situations, arising from the dynamic interplay between the polar abstractions of yin and yang.

Yin can be understood metaphorically by equating it to the earth, moon, night, winter, interior. It corresponds to all that is contractive, responsive, and conservative and is sometimes related to the more feminine

side of nature, meaning receptive, reflective, and intuitive.

Yang, on the other hand, can be associated with heaven, sun, day, summer, surface. It implies all that is expansive, aggressive, and demanding, and serves as the masculine counterpart of nature, meaning assertive and controlling.

Waves dancing to become mass exemplify the yin pole; the expansive dance to become energy, the yang. The more electrons are constrained by a "yin" pull, the faster and faster they dance (yang). The contractual pull gets complemented by the momentum and expansion pull, keeping the atom in optimal, dynamic equilibrium. These "pulls" are not exterior forces but arise out of the inherent nature of matter. Just as the mystics speak of too much of either pole as destructive, so too contemporary physicists. While too much contraction results in black holes, too much expansion results in burning suns.

Influence of Early Science on Education

This new scientific world view is vastly different than the one utilized in education today. To date, although many different models have been tried, they all seem to stem from two basic perspectives, either empiricism or maturationism. While empiricists rely too heavily on a controlled, Newtonian view, maturationists can be criticized for their sole reliance on the internal, natural development of the child, a view reminiscent of early science.

Empiricism

Definition. Empiricism is defined by Webster as "the theory that all knowledge originates in experience". Generally, empiricists hold that

Knowledge is a copy of a world exterior to the self. Stimuli effect the learner and are processed. Each experience or observation adds to prior ones, thus knowledge is the sum total of observations the learner has had. No a priori thought on the part of the learner is assumed. Empiricism is frequently equated to logical positivism which holds that all meaningful statements are either analytic or conclusively verifiable or at least confirmable by observation and experiment.

Empiricism in education. The empiricist viewpoint in education takes the form of preplanning a curriculum by breaking a content area or skill into assumed component parts or subskills and then sequencing these parts into a hierarchy ranging from simple to more complex. It is assumed that observation or experience at each of these sub levels will quantify to produce the whole, or more general concept. Further, learners are viewed as passive, in need of motivation, and effected by reinforcment. Thus, teachers spend their time developing a sequenced, well structured curriculum and determining how they will assess, motivate, reinforce, and evaluate the learner, before they have even met him/her! The child is simply tested to see where he/she falls on the curriculum continuum and then expected to progress in a continuous, quantitative fashion.

Bloom's mastery learning model is a case in point. This model makes the assumption that wholes can be broken into parts; that skills can be broken into subskills. Learners are diagnosed as to the level or subskill needed, then taught until mastery is achieved at each level. Further, it is assumed that if mastery is achieved at each level then the more general skill encompassing the parts has also been taught. Learners are assessed at each stage, because in true lcgical positivist fashion it is believed that learning can be conclusively verified by observation and experiment. The

effect of simply asking a question, or testing, is rarely considered, or if considered is usually cast empirically.

Problems. A recent study in the Chicago Public School System (1985) found an empiricist educational technology to have some problems. The Chicago schools adopted a mastery learning approach in their reading instruction programs, K - 6. The subskills such as beginning consonant sounds, vowel sounds, ending consonant sounds, consonant blends, vowel digraphs, and comprehension were taught in a structured, sequenced manner until mastery was achieved at each level. Teachers found that in the first few years of the program reading achievement scores increased. By sixth grade however an interesting fact was observed. Although reading scores were high on achievement tests, upon entering junior high, reading levels decreased. In fact, learners actually were found to not be reading. A research group brought in to study the problem found that although learners were scoring high on achievement tests, the tests were only measuring what had actually been taught, i.e. the subskill or component part covered. Learners in fact were spending most of the allotted language arts time completing dittoes or workbook pages related to the subskill, but were spending only a few minutes a day actually reading! Although they had mastered each component skill in isolation they were still not reading for meaning, enjoyment, or information. To wit, the parts did not necessarily add up to the whole; the whole was in fact larger than the parts.

Most elementary and secondary schools take an empiricist perspective in their curriculum planning. Fields are isolated and categorized as if they were really separate entities, e.g. science, math, reading, etc, and then they compete with each other for time in the overall curriculum. Subskills are identified, and sequenced into preplanned curricula. Learners are

diagnosed, motivated, reinforced, and posttested. The role of the teacher has become one of technician: diagnose the needs of the learner then present the correct sequence of objectives in the correct instructional mode. Even the teacher gets evaluated. Not only are the students' test scores used to validate what they have learned, but in some circles they are even considered an appropriate measure of the teacher's performance!

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Problems. Education viewed from this perspective eventually arrives at a dilemma, aptly described by Eleanor Duckworth (1987) in the title of her article, "Either they know it already and we're too late, or we're too early and they can't learn it anyway." Education dissolves to a game of constant assessment and matching, and leaves the question of how to help learners "get ready" unanswered.

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A New Model-- The Dance of Construction

Capra, in The Turning Point (1982), uses this new world view of relativity, not only to define technology, but to reflect on society, its institutions, and the rising culture. He states,

"Many (of today's physicists) actively support a society which is still based on the mechanistic, fragmented world-view, without seeing that science points beyond such a view, toward a oneness of the universe which includes not only our natural environment but also our fellow human beings."

The rise in nuclear armaments and our present economic and medical models are viewed by Capra as residual of a "Newtonian technology". Wholes are dissected, problems with parts are diagnosed, and solutions are proposed with no eye towards the relatedness of the parts, nor the effect of the observer. He continues,

"The yang, masculine consciousness that dominates our culture has found its fulfillment not only in 'hard' science but also in the 'hard' technology derived from it. This technology is fragmented rather than holistic, bent on manipulation and control rather than cooperation, self-assertive rather than integrative, and suitable for centralized management rather than regional application by individuals and small groups. As a result, this technology has become profoundly antiecological, antisocial, unhealthy, and inhuman. What we need is a redefinition of the nature of technology, a change of its direction, and a reevaluation of its underlying value system. If technology is understood in the broadest sense of the term, as the application of human knowledge to the solution of practical problems, it becomes clear that we have concentrated too much on ...rd' highly complex, resource-intensive technologies and must now shift our attention to the 'soft' technologies of conflict resolution,

social agreements, cooperation, recycling, and redistribution. As Schumacher says in his book Small is Beautiful, we need a 'technology with a human face'."

The new science model suggests a new technology of education, one of an organic/systems approach. A middle ground position is needed, more yin than yang, more yang than yin. If motion and change are essential properties of things and the forces causing the motion are not outside the objects but are an intrinsic property of matter, then learning and behavioral change become understood as self-regulated behavior of the child as she interacts with the environment. The teacher must seek to promote growth. She can be facilitative of this process, but she cannot force it. She must dance <u>with</u> the child, at times in unison, at times creating dissonance. Piaget's proposed mechanism of learning, equilibration, provides an interesting solution.

<u>Biological equilibration.</u>

In order to fully understand equilibration, a discussion of Piaget's early work with snails will be helpful. Piaget's fascination centered around the variability of the snail's adaptation. He studied three separate groups of Limnaea stagnalis (see figure 1): those that live in still, tranquil

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waters (habitat A), those that live in mildly disturbed waters agitated by waves (habitat B), and those that live in severely disturbed waters agitated by high winds and waves (habitat C). While the shape of the snail in calm

water was elongated, the shape of the snails in the agitated water was globular and curved. Piaget believed that the globular shape was due to the activity of the snails.

> "the animal in the course of its growth attaches itself to its solid support, which dilates the opening. At the same time and even because of this, it draws on the muscle that attaches it to its shell, and this tends to shorten the spine ,i.e. the upper part of the spiral shell" (Gallagher and Reid, pg. 22, 1982).

The interesting aspect that Piaget noticed was that the globular snails of habitat B, when removed and placed in an aquarium (habitat A) had offspring that were elongated! This showed that the change in structure was only a phenotypic change, not a permanent genetic change. In contrast the snails in habitat C, although they looked exactly like the snails in habitat B, showed no change even when they were left in an aquarium for 16 years. In other words, the snails in habitat C were distinctly different, having a different genotype.

From these observations, Piaget proposed a middle ground position between the commonly held theories of Lamarck and Darwin. Lamarck had very early suggested that evolution was a result of the organism's adjustment or accommodation to the environment's pressure. In other words, in order for a species to survive in a changing environment it made progressive structural, genetic changes. For years scientists cut tails off rats in an attempt to produce a genetic strain without tails. This act was fruitless and eventually Lamarck's theory was disproven.

Whereas Lamarck took a radical empiricist view, Darwin placed heavier emphasis on the organism. He proposed that evolution was due to random mutations generated by the organism. Whichever mutations were more suited to

the environment would be carried on.

Piaget took the position that behavior drives the evolution of new structur. because the development of new behavior, more or less, causes an imbalance in the genome, the regulatory system of the genetic structure and a new adaptation to the environment is constructed. He felt that both Lamarck's and Darwin's theories were too radical. He viewed behavior and the organism as a whole system; the balance between the structure of the organism and the environment were all interrelated and thus indissociable. Any change in a part of the system would result in other changes as behavior balanced the structure of the organism against the characteristics of the environment. Thus Piaget believed that, in the case of the snail, progressive reorganizations, or gradual changes in the response of the genome to the environment and the activity of the organism caused " a genetic assimilation whereby the genome entered into an interaction with the environment. The final result is the process of biological phenocopy: the replacement of an initial phenotype by a genotype presenting the same distinctive characteristics" (Gallagher and Reid, 1982, pg. 22).

<u>Cognitive equilibration</u>

Although Piaget's early work was in the field of biology, most of his life was devoted to studying the genesis of cognitive structures and relating this process to his early work in biology.

<u>Structures.</u> A structure, according to Piaget, is a system with a set of laws that applies to the system as a whole and not only to its elements. Structures are characterized by three properties: wholeness, transformation, and self-regulation.

<u>Wholeness</u> refers to the fact that the system is a whole that may in fact

be larger than the sum of its parts. The parts, interacting and related, are indissociable from each other and the whole and thus have no meaning by themselves. Their meaning is derived only in terms of the whole, and in relation to each other.

Transformation explains the relations between the parts, how one part becomes another. It pertains to the rules involved in the changing nature of the parts.

Each structure is also self-regulating, meaning that structures inherently seek self maintenance and closure. No matter what operations we do on the structure we still stay within the system. Piaget points out that no discussion of structures would be intact without a discussion of rhythm.

> "regularities in the non-technical sense of the word which depend upon far simpler structural mechanisms, on rhythmic mechanisms such as pervade biology and human life at every level. Rhythm too is self-regulating, by virtue of symmetries and repetitions. Rhythm, regulation, and operation---these are the three basic mechanisms of self-regulation and self-maintenance" (Piaget, 1970).

The concept of whole numbers illustrates well the notion of structure. When we add two whole numbers together we stay within the system of whole numbers (self-regulation). The numbers themselves have no meaning except in relation to each other (wholeness); 5 has no meaning except as 1 more than 4 or 1 less than 6, etc. And, we have many transformational rules explaining the relation between the parts such as adding 2 to 3 gives 5. Such rules are reversible thus we know with logical necessity that $5 - 3 = 2$. We also have rules dealing with associativity and commutativity, thus goals are attainable by alternative, compensatory routes.

Contemporary physics models depict the atom as a structure. Probing

into the particulate nature of the atom has shown the parts to be only constructs of the observer, dependent on the interaction with the other constructs. Specifically, the properties of mass depend on the momentum. This dependency is not unidirectional, but compensatory; momentum also depends on the properties of the mass. Thus the atom can only be understood as a continual dance of energy, a structural system where the parts interrelate and take on definitions only in relation to each other. Although the parts are indissociable, transformational rules can be derived to explain the changes occurring within the atom. For example, these rules explain well the process of how a photon becomes a wave and how momentum affects the mass of the particles. The rules, in fact, explain the self-regulatory nature of the atom, its rhythm and operations. As the mass increases the momentum to expand does also but it is complemented by the inward pull of the mass. Thus the particles dance between the poles of expansion and contraction to maintain an optimal balance, a structural system of interwoven parts in rhythmic harmony.

Genesis of structures. Although Piaget was interested in illuminating cognitive structures, he was far more interested in their genesis. He wrote, "The subject exists because, to put it very briefly, the being of structures consists in their coming to be, that is, their being 'under construction'....There is no structure apart from construction" (Piaget, 1970, pg. 140). In essence he believed that the human was a developing organism, not only in a physical, biological sense, but also in a cognitive sense. Because he viewed the organism as a whole system, a structure (such that emotional, cognitive, and physical development were indissociable constructs), he showed that the mechanism promoting change in each of the domains was the same, that of equilibration. Thus not only was it

equilibration that brought about the structural changes in the snail in its evolution, but it was also the mechanism that explained cognitive development. In fact, it was believed, by Piaget, to be the mechanism inherent in any transformational, growth process.

He understood equilibration as a dynamic process of self-regulated behavior balancing two intrinsic polar behaviors, assimilation and accommodation. Assimilation is the organization of experience due to one's own logical structures or understandings. It is the individual's self-assertive tendency, a tendency to view the world through one's own constructs in order to preserve one's autonomy as a part within a whole system. Piaget, at times, has called it the "reach beyond the grasp", the search for new knowledge, new territory. The organism attempts to reconstitute previous behaviors to conserve its functioning but every behavior results in an accommodation which is a result of the effects or pressures of the environment. In other words, new experiences, "new territory", sometimes contradict our present understandings making them insufficient, thus we accommodate. Accommodation is comprised of reflective, integrative behavior which serves to change one's own self and explicate the object in order to function with cognitive equilibrium in relation to the object.

<u>An example of cognitive equilibration.</u> One of the tasks used by Piaget to demonstrate equilibration in action utilizes seven discs, placed in a row and connected by chains to each other so that a comparison with discs other than the neighboring ones is impossible. Only the last disc, G, can be removed and compared to each disc in the series (see figure 2). The discs

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Place figure 2 here.

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increase in diameter, but only by an imperceptible amount. Since G can be removed and compared to all the others, however, the perceptual illusion of them being all the same size eventually becomes understood as an impossi-ibility. James, age 7, approaches the task stating that A is the same as B; B is the same as C; C is the same as D; D is the same as E; E is the same as F; and F is the same as G. When asked to compare G to A, he states that G is the big one and all the others are little ones. Then he proceeds to say that G is the same as F, which is the same as E, which is the same as D, etc. The contradiction (G=A, G is larger than A) in his logic is not apparent to him. His assimilatory scheme is one of relying on perceptual comparisons and measuring part, to part, to part. Eventually the illogic of his prior assimilatory scheme begins to bother him and he makes a few minor accommodations. At first he says that E, F, and G are the big ones and A, B, C, and D are little ones. This accommodation resolves the apparent contradiction that something cannot be big and small at the same time, and thus serves as a new assimilatory scheme; he sets out to determine which are the big ones and which are the small ones. A problem persists, however. Every time he is sure that he has two groups, small ones and big ones, he measures the two adjacent (e.g. D and E in the first attempt) and then thinks that he made a mistake. Maybe A, B, and C are the only little ones. Eventually he is right back where he started, with A the only little one. The insufficiency of this assimilatory scheme becomes apparent and another accommodation finally brings about a stable structural change, one which includes transitivity. He uses G to measure each of the discs and concludes that the only possible solution is that each disc is slightly larger than the one prior to it and that if one were to add the differences of A and B, B and C, C and D, D and E, E and F, and F and G, that amount would equal the amount

that G is bigger than A. The cognitive changes exemplified in the thinking of James did not occur in rapid succession, but instead were slow progressive equilibrations with development.

In order to fully understand equilibration, one has to think of it as a dynamic process, not a static equilibrium. Just as matter, when viewed by its particulate nature, is in a constant changing state dancing from mass to waves, so too, the learner. Equilibration is not a linear happening of first assimilation, then conflict, then accommodation. Instead it is a dynamic dance of progressive equilibrations, adaptation and organization, growth and change. As we assert ourselves and our logical constructs on new experiences and information we exhibit yang energy. Our reflective, integrative, accommodative nature is our yin pole. These two poles provide a dynamic interplay which by its own intrinsic nature serves to keep the system in an open, flexible, growth-producing state.

Constructivism

Definition. Philosophically, constructivists assert that we can never know the world in a "true" sense, separate from ourselves and our experiences, because we are an indissociable part of the world we are trying to understand. We can only know it through our present logical framework which transforms, organizes, and interprets our perceptions, and this logic is constructed and evolves through development as we interact with our environment and try to make sense of our experiences. Facts and theories which we hold as truths today, may be disproven tomorrow. To constructivists, cognitive development comes about through the same process as biological development--self-regulation or progressive equilibrations. We are, in a very real sense, "under construction."

Constructivism in education. Understanding learning as a self-regulatory process, equilibrating assimilation and accommodation, suggests that learning is an organic process of construction, rather than a mechanical process of accumulation. In contrast to empiricist/reductionist approaches, learning from a constructivist perspective is not seen as an accumulation of facts and associations. Rather, Piaget has conclusively shown that changes in cognition are made throughout development, producing qualitatively different frameworks of understanding. Although a maturationist also prescribes to such stages, he/she assumes they just unfold automatically. A constructivist takes the position that the child must have experiences hypothesizing and predicting, manipulating objects, posing questions, researching answers, imagining, investigating, and inventing. From this perspective, the teacher cannot ensure children get knowledge by dispensing it; a child-centered curriculum and instructional mode is mandated. The child must construct knowledge. The teacher needs to be a creative mediator in this process.

Communication itself even shows evidence of this interactive dance. A polarity appears to exist between listener and speaker. Recent film analyses (Leonard, 1981) show that every conversation involves a subtle and largely unseen dance in which the detailed sequence of speech patterns is precisely synchronized not only with minute movements of the speaker's body but also with corresponding movements by the listener. Both partners are locked into an intricate sequence of rhythmic movements. The work of Brazelton (1974), Tronick (1975), and Stern (1977), among others, demonstrates this same "rhythmic dance" between baby and caregiver.

From a constructivist perspective, education itself becomes a dance--a dance of interaction between learner and teacher, and learner and object.

Just as mass dances to become energy and energy, mass, so the poles of learner and teacher and learner and object form paradoxical, yet unified, relationships transforming each other. (See Fosnot, 1984 for a delineation of the principles involved in a constructivist approach to the technology of education.) The following observation in a K-2 classroom depicts the dance.

The dance in practice. The teacher grouped several children (ages 5 - 7) around her and brought out a die she had made. Each face had a number on it: 6, 7, 7, 8, 8, 9. Thus one face had a six; two faces had sevens; two faces, eights; and one face, nine. With large one inch graph paper, she and the children colored in squares to represent the faces. This process resulted in a bar graph showing one unit for six, two units for 7, two units for 8, and one unit for 9. Then she placed the die in a small box and asked the children to guess what number would show when she spilled the die onto the table. Around the table they responded, each giving his/her own reasoning for his/her choice. Several children chose their favorite numbers and said they thought it would turn up since it was their favorite. Others guessed randomly. The die was thrown and the face was recorded on a new sheet of large one inch graph paper. Several trials ensued, each one recorded, and each time children were asked for a guess and their reasoning. Several children began to guess 7 or 8, but their reasoning was based on the fact that 7 and 8 were showing up more frequently. After several more trials the teacher simply made the observation that it was interesting that the pattern showing up on the graph was similar to the one that represented the faces of the die. She left the children wondering why that was and then dismissed them for lunch.

Jed, a six year old in the group, looked bothered all through lunch. When he returned to the classroom he asked the teacher for the die and began

throwing it again. All of a sudden his face lit up and he went running to the teacher. "Teacher, teacher guess what I just figured out? I know why the sevens and eights kept coming up...There's two of each on the die!"

"Why does that matter?" queried the teacher.

"Well you see each time it falls it could land on this side (top face with a seven) or on this side (bottom face with a seven). There's more chances for a seven than a six or a nine."

"By golly, I think you've got something there!" commented the teacher. Then she quieted the class so that Jed could share his discovery with everyone.

Jed had constructed the beginning notions of probability. Better put, Jed was in the midst of "inventing" probability. The teacher had facilitated self regulatory learning by dancing with him. She had not forced the notion of probability on Jed by explaining the principle, externally motivating him to learn it, and then reinforcing it. Nor did she just sit back and wait for it to be constructed out of his play. Instead, she arranged a situation conducive to cognitive conflict by using a predict consequence approach. Further, she entered into the dance by focusing attention on the similar patterns in the graphs. Most importantly though, she had provided dissonance for cognitive adaptation, and then respected his rhythm, moved to his tempo, and fostered his cognitive compensations.

Final Comments

The dance of education is the dance of growth and development; it's rhythm, the heartbeat. The interactions of learner and teacher, learner and object, form a melody like notes playing off each other: sometimes in harmony, sometimes with a Beethovian discordance of creative tension.

When a dance is evaluated it is viewed as a whole. The dancer is not assessed on how well he/she can piroutte, given scores on each skill and then a total. He/she is evaluated interacting with the music, the other dancers, and the audience. So too, perhaps the only way to assess the child learning is to assess the moment; to look at the processes such as assimilation and accommodation; to study the compensations as they occur in the interactions between teacher, object, and learner; to value their rhythms and melodies. Assessing skills out of context of the learning situation is like evaluating a dancer after the performance, but not during it. In the words of the physicist, Capra (1982),

"There is motion but there are, ultimately, no moving objects; there is activity but there are no actors; there are no dancers, there is only the dance."

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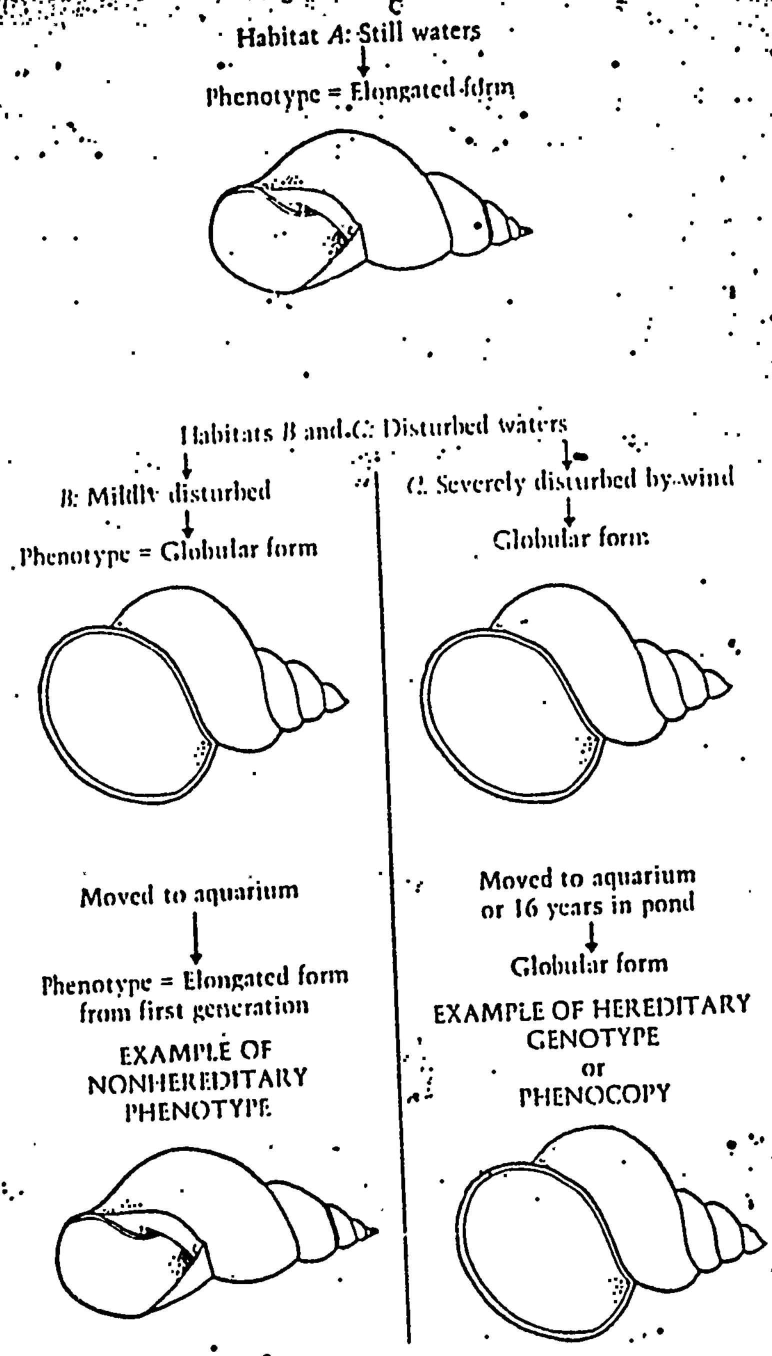
Figure 1



[redacted] Pond snail *(Limnaea stagnalis)* as an example of phenocopy. (Based on Piaget, 1971a, 1974a, 1977a, 1977c.)

Figure 2

The Disc Problem